

## Farm types and farmer motivations to adapt

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1 **Farm Types and Farmer Motivations to Adapt: Implications for Design of Sustainable**  
2 **Agricultural Interventions in the Rubber Plantations of South West China**

3

4

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23

24

25 **Abstract**

26 Tropical land use is one of the leading causes of global environmental change. Sustainable agricultural  
27 development aims to reduce the negative environmental impacts of tropical land use whilst enhancing the well-  
28 being of the small holder farmers residing in those areas. Interventions with this goal are typically designed by  
29 scientists educated in the Western tradition, and often achieve lower than desired uptake by small holder farmers.  
30 We build on work done in farm type classification and studies of factors that influence adaptation, trialling a suite  
31 of household survey questions to elucidate the motivational factors that influence a farmer's willingness to adapt  
32 to external change. Based on a sample of 1,015 households in the rubber growing region of Xishuangbanna,  
33 South-west China, we found that farm types based on structural characteristics (e.g. crops, livelihoods) could not  
34 be used to accurately predict farmers' motivations to adapt. Amongst all six farm types identified, the full range of  
35 motivational typologies were found. We found six motivational types, from most to least likely to adapt, named:  
36 Aspirational Innovators, Conscientious, Copy Cats, Incentive-centric, Well Settled, and Change Resistant. These  
37 groups roughly corresponded with those identified in literature regarding diffusion of innovations, but such  
38 classifications are rarely used in development literature. We predict that only one third of the population would be  
39 potentially willing to trial a new intervention, and recommend that those sectors of the population should be  
40 identified and preferentially targeted by development programs. Such an approach requires validation that these  
41 motivational typologies accurately predict real behaviour – perhaps through a panel survey approach. Dedicated  
42 data gathering is required, beyond what is usually carried out for ex-ante farm typologies, but with some  
43 refinements of the methodology presented here the process need not be onerous. An improved suite of questions to  
44 appraise farmers' motivations might include value orientations, life satisfaction, and responses to various  
45 scenarios, all phrased to be locally appropriate, with a scoring system that uses the full range of potential scores  
46 and a minimum of follow up and peripheral questions.

## **1. Introduction**

Tropical land use for the past century has been dominated by conversion of forested lands to agricultural land, leading to loss of biodiversity (Barnes et al., 2014; Gibson et al., 2011), increased carbon emissions (Houghton et al., 2012; Le Quéré et al., 2014), changes in evapotranspiration patterns (Lawrence and Vandecar, 2015; Zhang et al., 2016), and the degradation of ecosystem services (Foley et al., 2005; Power, 2010). Proposed solutions tend to focus on the potential benefits that solutions could bring (e.g. Foley et al., 2011) or on evaluating the trade-offs in selecting one solution over another (Phalan et al., 2011). However, in most situations the decision to adapt one's behaviour is not taken by experts, but by small holder farmers. In a recent review, enhanced adoption of sustainable agricultural interventions was linked to three features of projects: a fine-scale understanding of local needs, appropriate market and service mechanisms, and engaging adopters through the research process (Coe et al., 2014). These are particularly salient in situations of decentralised decision making, as occurs where many small holder farmers are responsible for a mosaic landscape (Fox and Castella, 2013), which is the case across much of the tropics.

Rubber plantations in montane south east Asia have expanded leading to rapid replacement of diverse landscapes with monocultures, and giving rise to serious concerns about forest loss, ecosystem degradation, biodiversity loss and risky over-specialisation of livelihoods (Ahrends et al., 2015; Fox et al., 2014; Warren-Thomas et al., 2015; Ziegler et al., 2009). Scientific literature to date generally has focused on either potential management interventions (De Blécourt et al., 2014; Fu et al., 2010; Liu et al., 2015; Riedel et al., 2012; Thongyou, 2014; Viswanathan and Shivakoti, 2008), or potential policy interventions (Cotter et al., 2014; Smajgl et al., 2015b; Yi et al., 2014b). The efficacy of policy interventions is however determined by the interaction between policy mechanisms and the grass-roots responses (Smajgl et al., 2015a), therefore understanding the motivations of small holder farmers to adapt their practices is essential in designing appropriate interventions.

Farm typologies are one method for understanding how different segments of a farming population might react to proposed interventions. Farm typologies are typically based on observable structural characteristics such as farm size, household size, crops grown, livestock raised, and incomes. These farm typologies are useful in determining which interventions are appropriate to specific types of farm and form the basis for many ex-ante intervention and

76 prioritization analyses (Bongers et al., 2015; Herrero et al., 2014; Rufino et al., 2013; van Ittersum et al., 2008).  
77 The structural characteristics of a farm do not present the whole picture, however, and there is a temptation to use  
78 the structural characteristics to calculate the most efficient path to intensified production which disregards the  
79 system complexities that farmers deal with in their daily lives (van der Ploeg et al., 2009). Van der Ploeg *et al*  
80 (2009) found that consideration of the balance of livelihood activities and farmers' objectives can help to explain  
81 the plurality of farm styles, when considered in combination with the farm structural characteristics. Indeed, the  
82 diversity of farmers' characteristics can render interventions which try to address the 'average farmer' redundant  
83 (Marshall and Smajgl, 2013). Targeting interventions according to farmers' motivations may be a more fruitful  
84 approach: for example farmers with conservation oriented attitudes are correlated with a higher willingness to  
85 adapt practices in a way which enhances conservation goals, and that those farmers who are strongly  
86 economically oriented require financial incentives in order to adapt (Greiner et al., 2009). Meijer et al (2014)  
87 categorised factors influencing farmer motivations into 'extrinsic' and 'intrinsic' factors, where extrinsic are  
88 demographic, economic, geographical, and intrinsic are related to knowledge, perceptions, attitudes; and found  
89 that intrinsic factors in particular are often overlooked (Meijer et al., 2014). The goal of the present study was,  
90 therefore, to improve understanding of the relationship between the 'structurally' oriented farm types, and the  
91 different groups of factors which motivate farmers to adapt their behaviour. We posit that farmers' willingness to  
92 adapt is key to adopting new practices, and that understanding the farmers' motivations to adapt is therefore key to  
93 increasing adoption rates. From household survey data, we constructed one typology based on farm structural  
94 characteristics and livelihoods, and constructed a separate typology based on farmer motivations to adapt. We then  
95 assessed the linkages between the two groupings, and drew out the implications for design of agricultural  
96 interventions with a higher adoption potential.

97

## 98 **2. Methods**

99 Xishuangbanna is an autonomous prefecture of about 19,000 km<sup>2</sup> in Yunnan province, southwest China. Together  
100 with Hainan island, it is the only area of sub-tropical forest inside China's borders. The average temperature in  
101 Xishuangbanna is 20-22.5°C, with an average high temperature of 25-27°C occurring in May-June. Average  
102 precipitation is 1200-1800mm per year and the wet season lasts from May to October during which 90% of the  
103 rain falls. The terrain is densely undulating, land elevation ranges from 400 to 2,400 metres above sea level, and  
104 there are four bio-climatic zones: warm temperate and moderately moist (high elevations); hot and moderately

105 moist; extremely hot and moderately moist; and extremely hot and moist (low elevations) (Zomer et al., 2014).  
106 The primary crops are rubber, tea, and rice.

107 Xishuangbanna was originally heavily forested. In 1976 forests accounted for about 70% of land mass (Li et al.,  
108 2006). There has been a trend of deforestation since then. Accurate figures on deforestation are difficult to acquire  
109 from official governmental sources. However, two systematic studies of satellite imagery between 1976 and 2003  
110 (Li et al., 2009, 2007) found that by 2003 forest cover in Xishuangbanna shrank from 69% to less than 50% of the  
111 landscape; that the important tropical seasonal rainforest shrank from 10.9% to 3.6%. There has been no  
112 systematic study of forest area since 2003; but we may infer that deforestation has increased, as the amount of  
113 land planted with rubber almost tripled between 2002 and 2010, from 153,000 ha to 424,000 ha (Xu et al., 2014).  
114

115 Household survey data was gathered in a single campaign during 2010, in 50 villages, amongst two counties  
116 within the province of Xishuangbanna, South West China (Table 1). One thousand and fifteen households were  
117 interviewed. Villages were selected in discussion with government officials to cover the full altitude gradient of  
118 the rubber growing region, distributed across seven townships where rubber cultivation is prevalent. Three or four  
119 village committees were selected per township, and then two natural villages per village committee, making a  
120 total of 50 villages. Households were then selected at random from the government village register.

121 Altitude varied amongst the surveyed villages from 500m above sea level to 1600m. This altitude range strongly  
122 effects the viability of certain crops (rubber, coffee, tea); different ethnic groups tend to inhabit specific locations  
123 which can be defined by altitude; and altitude can also be seen as a rough proxy for development, where the  
124 communities at lower altitudes tend to have more developed educational, transport and market infrastructure.  
125

126 \*\* Insert Table 1 \*\*  
127

128 The survey consisted of a ten-page printed questionnaire which took approximately one and a half hours to  
129 complete and was implemented in Mandarin Chinese. The survey was written by Smajgl and Ward (co-authors to  
130 this manuscript), and has been described elsewhere (Hassenforder et al., 2015; Smajgl et al., 2016, 2015c, Smajgl  
131 and Ward, 2015, 2013). The main topics covered were household demographics, ownership of assets including  
132 land, livelihood activities and incomes, personal value orientations, attitudes, perceptions of the likelihood of  
133 future events, and stated intentions to adapt under four hypothetical scenarios.

Household demographics included questions on family size, education, location, and ethnicity. Assets included farm size and land uses, as well as vehicles, machinery, and domestic appliances. The livelihoods section included crop and livestock yields and incomes, off-farm incomes, and non-cash gifts. Together, the data on household demographics, assets, and livelihoods are referred to from here on as ‘farm characteristics’.

The data on value orientations, attitudes, likelihood of future events and stated intentions to adapt are used to inform about farmers’ motivations to adapt their behaviour, and are referred to from here on as the ‘motivations’ data. The conceptual basis is that personal values influence value orientations, which influence attitudes and norms, which influence stated intentions, all of which influence actual behaviours. Through measurement of some of these variables it may therefore be possible to predict actual behaviour. A recent review explains this in more detail (Jones et al., 2016), and links between these variables have been well established (de Groot and Steg, 2007). Nevertheless, the degree to which a typology based on these variables can predict actual behaviour in a context of rural development has not been proven. Such a proof would require an initial survey to establish a baseline and a motivation typology, predictions to be made, and then a follow up survey to establish if the predictions were accurately matched actual behaviour. This work is only able to complete the initial steps of establishing a baseline and motivation typology, and making some predictions about farmer behaviour. A follow up survey would be required to establish the accuracy of the predictions. Acknowledging this limitation, we divide the population into sub-groups according to their differing motivational traits, where the assumption is that these sub-groups would behave differently. We then relate the motivational sub-groups to the more traditional typology based on observed ‘farm characteristics’.

Value orientations are based on the theory that there are underlying values which are common world wide, and which can be elucidated using a standardised set of questions (Schwartz, 1992; Schwartz and Bilsky, 1987). The standardised questions have been streamlined for easier use (Stern et al., 1999, 1998) and tested in subsequent work (de Groot et al., 2008; de Groot and Steg, 2007). The five value orientations are: altruistic, egoistic, biospheric, openness to change, and traditionalism. Altruistic, also referred to in the literature as self-transcendence, means having interests in the well being of others. Egoistic, also referred to as self-enhancement, means improving one’s own situation in life. Biospheric means having an interest in the well being of non-human life. Openness to change and traditionalism (also referred to as conservatism) represent opposite poles in terms of likelihood of trying out new ideas or practices. A more complete explanation of these terms and their empirical testing is provided in a recent review (Dietz, 2015). Three questions were used to appraise each of the five value

orientations (Smajgl and Ward, 2015), and the mean was used to determine the score for each value orientation. The interviewees' attitudes towards up to eight variables related to economy, environment and community were gathered using numerical scales between 0-10 to assess their perception of the 'importance of' each variable and their 'satisfaction with' each variable. Interviewees were asked select up to eight variables from a longer list of 38 and then scored the selected variables. They were also asked to rate their overall life satisfaction on a scale of one to ten.

The subjects' predictions for near future changes regarding natural resource decline (e.g. water, soil), farming practices (e.g. mechanisation, market orientation) and wider socio-economic changes (e.g. urban employment, increased tourism) were gauged using a modified seven-point Likert scale for both perceived likelihood and perceived impact upon the household. Eight questions were asked for each futures theme (Ward and Poutsma, 2013), which were then used to determine a mean score for each theme.

Finally, four hypothetical scenarios were outlined with multiple choice answers offered to the respondent. The four scenarios were: a 50% drop in the value of their main crop, lucrative urban employment opportunities, unpredictable climate change (hotter and dryer), and a government subsidy program for native trees replacing rubber trees, matching present income. The four scenarios were chosen through a multi-level participatory process (Smajgl et al., 2015a; Smajgl and Ward, 2015), where the first three were selected as feasible future scenarios and the fourth as a potential government intervention (Smajgl et al., 2015b)

The options available to respondents were: to ignore the scenario and carry on as usual, modify their current behaviour in some way, completely replace their current behaviour, or leave and go to a new place. Follow up questions were then asked probing the reasons for their decision, and if they decided to modify their behaviour, what would they modify and to what degree, and if they chose to migrate where would they go, for how long, and what would they do. [The full questionnaire has been archived on Dataverse.](#)

Once gathered, the data was compiled into a Microsoft Excel spreadsheet. Four observations were dropped due to missing data points or inexplicably high outlier values. Data analysis was conducted using R (R Core Team, 2012) and R Studio software (RStudio Team, 2016), and using the following packages: *vegan* (Oksanen et al., 2016), *multcomp* (Hothorn et al., 2008), *ggplot2* (Wickham, 2009a), and *plyr* (Wickham, 2009b).

The two datasets ('farm characteristics' and 'motivations') were analysed separately, although both datasets went through a similar analytical process. The objective was to generate a meaningful typology based on each dataset, and then explore to what degree a typology based on farm characteristics can predict farmers' motivations to



192 adapt. Typologies were generated using a hierarchical cluster analysis (Kaufman and Rousseeuw, 2009) of the  
193 most informative variables in each dataset . The most informative variables were selected using principle  
194 component analysis (PCA) (Jolliffe, 2002). Once derived, all variables were mapped onto the clusters and the  
195 clusters were interpreted as typologies. Significance of difference between clusters (‘farm types’) for individual  
196 variables was tested using a post hoc Tukey test of honest significant difference (Jaccard et al., 1984). Up to this  
197 point the methodology followed the approach commonly outlined in manuals for multivariate statistical analyses  
198 (Coghlan, 2013; James et al., 2013). The independence of the 'farm characteristics' typology and the 'motivations'  
199 typology was tested using a Pearson’s Chi squared test, and redundancy analysis (RDA) (Legendre and Legendre,  
200 2012; Ter Braak, 1986) was used to determine the degree to which certain farm characteristics variables could be  
201 used to predict farmers’ motivations.

202 Prior to the PCA logically incompatible variables were excluded and remaining variables checked for normality of  
203 distribution. Where necessary and possible transformations were applied to bring distributions close to normal.  
204 Variables were dropped from further analysis if they were strongly correlated with another variable on all  
205 principle components, or if they showed little correlation with any principle component. Prior to cluster analysis  
206 variables were re-scaled to similar ranges. Cluster analysis was performed using a Gower dissimilarity matrix  
207 (Gower, 1971), which permits mixed data types including of numeric, ordinal and categorical data. Some data that  
208 were not appropriate for principal component analysis (e.g. multiple choice scenario responses) could therefore be  
209 included in the cluster analysis, along with the variables identified as most important through the PCA. The Ward  
210 minimum variance clusters method (Ward, 1963) was used to perform the hierarchical cluster analysis on the  
211 dissimilarity matrix. The final number of clusters was selected according to the point at which the explanatory  
212 power of further cluster subdivisions plateaued (see Supplementary Material Figures S1 and S2).

213

## 214 **3. Results**

215

### 216 **3.1 Farm Characteristics: Site Overview**

217

218 Households had a mean size of 4.3 members, median farm size of 2.9 ha, and median gross income of 7,500 USD  
219 per year. All incomes are referred to in gross terms. Both the farm size and the total income were highly variable,

220 with standard deviation approximately as large as the mean. The median amount of land per person was 0.75 ha  
221 and the median income per person was 5.1 dollars per day. Median agricultural incomes accounted for 5900 USD  
222 per household per year (or 2900 USD per hectare), and off-farm incomes 450 USD per household per year. In  
223 terms of income the study population is wealthier than most farmers in developing countries, which is due to the  
224 prosperity brought by the rubber boom and also to the rapid and sustained growth in China's economy.

225

226 The major crop for most households was rubber. Sixty-seven percent of households rated rubber as their most  
227 important and most reliable crop. Tea was rated as most important and most reliable by 24% of households and  
228 4% of household rated maize as their most important and reliable crop. The most commonly practised agricultural  
229 activities were as follows; rubber (82%), rice (60%), maize (55%), livestock (54%), tea (37%), horticulture (15%),  
230 fruit trees (6%). Median annual incomes from those crops were as follows: rubber (\$5900), rice (\$0), maize (\$0),  
231 livestock (\$250), tea (\$1200), horticulture (\$200), fruit trees (\$450). Rice and maize were widely grown crops but  
232 were generally used for household consumption and feeding of livestock – hence median income values of \$0  
233 from those crops. Note that the median value of crops is calculated only from households who reported growing  
234 that crop. Other minor activities mentioned were fishing and aquaculture, forestry, forest products and mushroom  
235 cultivation. Households on average practised three agricultural activities.

236

237 Almost all households (97%) had some form of off-farm income, but usually from passive sources, such as state  
238 subsidies (which 72% of household received), income from rental of land (42% of households), pensions (18% of  
239 households), and governmental compensation for land lost to industrial developments (5%). Active employment is  
240 much less common. The main activities and the proportion of households who undertook active off-farm activities  
241 were as follows; family business (e.g. shop, restaurant) (9%), government employment (8%), agricultural  
242 labouring (5%), tourism (3%), construction (3%), services (2%), and remittances (1%). The passive activities are  
243 typically lower income. Median annual incomes from off-farm activities were as follows; subsidies and pensions  
244 (\$100), land rental (\$950), land compensation (\$650), family business (\$2500), government employment (\$200),  
245 agricultural labour (\$650), tourism (\$1500), construction (\$1300), services (\$450), remittances (\$500). Again the  
246 median values are calculated only from households who report receiving some income from that activity.

247

248 Six ethnic groups were reported. Listed in decreasing order of frequency, they were Dai, Akha, Yi, Bulan, Han,

249 and 'other'. Household heads were typically reported to be male (96%) with an average age of 46 years. Fifty  
250 percent of household heads had received primary education and 19% reported basic secondary education. Twenty-  
251 five percent were illiterate. Youth education (youth defined as children of household head) was higher, with over  
252 fifty percent reporting basic secondary and approximately twenty percent reporting advanced secondary. Only 2%  
253 were illiterate. About half of the surveyed households were at lower elevations (500-700m), about one quarter at  
254 mid elevations (700-900m) and the remainder at high elevations (900-1600m).

255

256 3.2 Farm Characteristics Typology: Cluster Analysis

257 The following variables were used in cluster analysis: annual household income from rubber, fruit trees, tea, other  
258 agricultural sources combined, and off-farm incomes, number of agricultural and non-agricultural activities per  
259 household, farm size, age of household head, education level of household head and altitude above sea level.  
260 Selection of six clusters was identified as most appropriate, in order to keep the number of clusters manageable  
261 whilst showing the most meaningful diversity in farm characteristics (see figure S1 for justification). Verbal  
262 descriptions of the clusters are presented in Table 2 and numerical data (with significant differences marked) are  
263 presented in Table 3.

264

265 \*\* insert tables 2 and 3 \*\*

266

267 The six clusters (Tables 2 and 3) were named Young Rubber, Traditional Rubber, Rubber and Business, Mixed  
268 Cash Croppers, Tea Farmers, and Upland Mixed, and from here on will be referred to as 'farm types'. In the first  
269 four farm types the main source of income was rubber, total income was relatively higher and farms were located  
270 at lower elevations. The latter two farm types were poorer, resided at higher elevations and derived the bulk of  
271 their income from sources other than rubber farming.

272 Household heads in the Young Rubber farm type were younger and better educated than others, and engaged in  
273 more off farm activities than Traditional Rubber farmers, although their off farm incomes were not significantly  
274 higher. Traditional Rubber farmers focused primarily on rubber for income, maintained medium level of diversity  
275 of subsistence crops, relied more upon remittances than other farm types, and were also the worst educated of all  
276 farm types. The Rubber and Business farm type showed the highest frequency of (and incomes from) off-farm  
277 activities of all farm types, in addition to their rubber farming activities. Although the Mixed Cash Croppers

278 derived their main income from rubber, they also derived a substantial income from other agricultural activities,  
279 including livestock, horticulture, and most notably fruit trees and perennials, by far the most profitable of which  
280 was banana. The Tea Farmers reside at high elevations and relied on tea for the majority of their income,  
281 supplemented by some staple crops. Upland Mixed farmers were the poorest of all farm types, relying on a variety  
282 of staple crops, rubber and tea for income, as well as a moderate amount of off-farm work.

283 Livelihood activities per farm type are presented in Figure 1. Rubber was the major income source for the Young  
284 Rubber, Traditional Rubber, Rubber and Business, and Mixed Cash Crop farmers, generating a mean of around  
285 9000 USD per year per household (with standard deviation about the same as the mean, see Table 3 for means per  
286 farm type). Perennial fruits, such as banana, had the potential to generate large income of up to 10,000 USD per  
287 year, although only the Mixed Cash Croppers generated such a high income so far, and even that was relatively  
288 few farmers (<10% of the cluster). Tea generated a substantial income for the Upland Mixed farm type, of 2000 –  
289 3500 USD per year per household. Although other farming activities were widely practised (rice, maize, livestock,  
290 horticulture) the products were mainly for self consumption and sales of those products generated between 5 and  
291 20% of the household income. Most farm types derived a small proportion of their income from government  
292 subsidies and land rents (200 - 1000 USD per year). Far fewer households in all farm types engaged in the more  
293 profitable off-farm activities incomes. The average incomes per activity were highest from private businesses  
294 (including restaurants, shops, and trading agricultural produce) for most clusters at 3000 - 6000 USD per year.  
295 Farmers in the Upland Mixed and Rubber and Business farm types earned around 5000 USD per year in industrial  
296 work, and the Young Rubber cluster derived significant income from farm labouring work, although frequency of  
297 participation was lower than for private businesses.

298

299 \*\* Insert Figure 1, on livelihood activities per farm type. \*\*

300

### 301 3.3 Farmer Motivations: Site Overview

302

303 Households rated their overall life satisfaction at a mean score of 7.6. Satisfaction with economic factors was  
304 rated at 7.3, family factors at 8.7, and natural environment 8.0. Importance of the economy was rated at 9.5,  
305 importance of family at 9.7, and importance of natural environment at 9.4. The distributions of all 'importance'  
306 and 'satisfaction' responses were highly skewed towards the upper end of the scale. There was a particularly low

307 variance associated with measures of 'importance'.

308

309 Value orientations were calculated for five themes; egoistic, altruistic, biospheric, conservative, and innovation.

310 Mean scores on a scale of 0 to 10 were as follows: egoistic 7.0, altruistic 7.8, biospheric 7.6, conservative 8.2,

311 innovative 6.2. Conservative, altruistic, and biospheric value scores were skewed towards the upper end of the

312 scale, while the egoistic and innovative values were approximately normally distributed.

313

314 Perceived likelihood of future events and estimated impact upon the household were calculated for three broad

315 themes. Mean scores for likelihood, normalised to a scale of 0 to 10, were as follows; farming optimism 6.9,

316 environmental pessimism 6.2, and sweeping socio-economic changes 3.9. Mean scores for impact were; farming

317 optimism 6.1, environmental pessimism 6.7, and sweeping socio-economic changes 6.0. Distributions were

318 approximately normal.

319

320 The four scenarios outlined to the farmers were: a) a 50% drop in value of main crop; b) lucrative urban

321 employment opportunities; c) unpredictable climate change, and d) a government subsidy program for native trees

322 to match present income. For a projected halving in the value of main crop, 41% of the population said they would

323 ignore it and continue as normal, 57% said they would adjust their activities accordingly, 1% said they would

324 totally replace their activities with something new, and 0.2% said they would leave and go somewhere else.

325 Regarding the urban employment scenario, 73% said they would ignore the new opportunities, 23% said they

326 would adjust their activities, 3% said they would completely change their activities, and 0.3% said they would

327 leave and go somewhere else. Regarding the climate change scenario, 43% said they would ignore it, 50% said

328 they would adjust their activities, 6% said they would completely replace their activities, and 1.4% said they

329 would leave and go somewhere else. Regarding the native tree subsidies scenario, 30% said they would ignore it,

330 68% said they would adjust their activities, 0.5% said they would completely replace their activities, and 0% said

331 they would leave.

332

333 When households were asked why they would not leave and go to a new place, the most frequent response for

334 each scenario was "this is the village of our ancestors" (47-53% of responses chose this answer under each

335 scenario). Other answers given were "we would not be affected", "we're fine as we are", "we like what we are

336 doing”, and “we don't have the skills”. The other answers (“no money”, “need government support”, “too risky”,  
337 “no land in other place”) however were not consistently chosen between scenarios and were typically selected by  
338 around 10% of the population. When asked why households would not adjust their activities to respond to a  
339 scenario, the most common answers across all scenarios were “we like what we are doing” (20-40% selected this  
340 response). Other answers given were “we would not be affected”, “we're fine as we are”, “it would be too risky”  
341 and “we don't have the skills”.

342

### 343 3.4 Farmer Motivations Typology: Cluster Analysis

344

345 The following variables were retained and used in the cluster analysis: overall life satisfaction score, altruistic,  
346 egoistic, biospheric, and openness to change value scores, future environmental pessimism, future farming  
347 optimism, and frequency that the respondent reacted to the outlined scenarios. Six clusters were identified (see  
348 figure S2 for justification). Verbal descriptions of the farm types are presented in Table 4 and numerical data with  
349 significant differences between clusters are presented in Table 5.

350

351 \*\* insert tables 4 and 5 on motivation type clusters \*\*

352

353 The six clusters were named Aspirational Innovators, Copy Cats, Conscientious, Incentive-centric, Well Settled  
354 and Change Resistant, and from here on will be referred to as ‘motivation types’. The Aspirational Innovators  
355 scored the highest on innovation related indices – openness to change and stated willingness to adapt to scenarios  
356 – and also expressed discontent with their economic, family and environmental circumstances, although they  
357 maintained a positive outlook for the future, and hence were interpreted as aspiring to improve their situation. The  
358 Conscientious cluster also scored highly on innovation indices, altruistic values, and showed the highest levels of  
359 concern regarding environmental and social issues, and very high satisfaction scores. The Copy Cat motivation  
360 type expressed high willingness to adapt their activities, but scored low on personal values relating to openness to  
361 change and egoistic behaviour, implying that they are not so strongly driven to experiment as some other  
362 motivation types. Therefore although they would be willing to adapt their activities, they might prefer to copy  
363 someone else rather than be the first to experiment. The Incentive-centric motivation type were primarily  
364 motivated by financial incomes and scored moderately on innovation indices. The Well Settled motivation type

365 were generally satisfied with all aspects of their lives and did not feel much imperative to modify their activities.  
366 The Change Resistant cluster showed middling levels of satisfaction, no specific guiding values, and very little  
367 interest in altering their activities for any reason. The most numerous motivation types were Aspirational  
368 Innovators, Incentive-centric and Change Resistant, and the least numerous were the Copy Cats (see Tables 4 and  
369 5).

370

371 Figure 2 shows the reasons given by respondents as to why they would choose not to respond to the scenarios  
372 which were outlined to them, broken down by motivation type. The Change Resistant motivation type presented  
373 the most reasons in total why they would choose not to respond to external stimuli, and they presented the most  
374 diverse reasons, followed by the Incentive-Centric type, and then the Well Settled type. Aspirational Innovators,  
375 Copy Cats and Conscientious motivation types showed similar profiles to one another in terms of total number of  
376 barriers reported and diversity of reasons. The most commonly cited barriers to adaptation did not differ between  
377 motivation types, and indeed were the most commonly reported for the whole study sample: “we like what we are  
378 doing” and that the change would “not affect us”. Lack of money and the perceived risk of making changes also  
379 feature highly for all motivation types. Lack of skills, knowledge, infrastructural support and land were cited as  
380 barriers to adaptation only by the most change adverse motivation types (Change Resistant and the Incentive-  
381 Centric).

382

383 \*\* Insert Figure 2: Reasons given by motivation types for why they would not respond to scenario changes. \*\*

384

### 385 3.5 Linking the Farm Types and Motivation Types

386

387 The farm typology based on farming practices, livelihoods and household demographics showed almost no  
388 significant differences between the farm types in terms of motivations variables (few enough to be discarded as  
389 false positives). Likewise the motivation typology groups showed few significant differences in terms of  
390 livelihoods, farm practices or demographics. The only exceptions were that Aspirational Innovators, Copy Cats  
391 and Conscientious clusters tended to have more off-farm income activities than the other motivations clusters.  
392 This implies that farmers’ motivations to adapt cannot be inferred  
393 from standard farm typologies.

394

395 \*\* Figure 3 on cluster distribution amongst clusters \*\*\*

396

397 However, the frequency distribution of households in farm types and motivation types was significantly non-  
398 random (Pearson's Chi Squared,  $p < 0.01$ ), meaning that some motivation types are more common in some farm  
399 types. Figure 3 shows the proportions of different motivation types in each farm type. Each of the six farm types  
400 contains households in all six of the motivation types. Hence, there is no obvious, or invariant, link between farm  
401 characteristics and farmer motivations. Observations can be made by comparison of the observed frequencies of  
402 motivation types within each farm type, compared to the expected frequencies should motivations and farm types  
403 be independent, with the caveat that statistical significance cannot be attributed to individual observations. Figure  
404 3 illustrates this point: the Traditional Rubber, Tea Farmer, and Upland Mixed farm types show a higher  
405 proportion of households in the Change Resistant motivation type than would be expected (given independent  
406 distributions), where as the Young Rubber, Rubber and Business, and Mixed Cash Croppers show a lower  
407 proportion of household in the Change Resistant motivation type than would be expected. The Traditional Rubber  
408 farm type showed about one third fewer of the Aspirational Innovator motivation type than would be expected,  
409 and also Traditional Rubber and Tea Farmer types showed a higher proportion of the Well Settled motivation type.  
410 The Rubber and Business farm type showed notably higher proportions of motivation types more likely to adapt –  
411 Aspirational Innovators and Conscientious – and lower proportions of the motivation types less likely to adapt.  
412 Overall, we found significant evidence that farm type was linked to motivational type, and trends could be  
413 observed that three of the farm types (Traditional Rubber, Tea Farmers and Upland Mixed) were generally less  
414 likely to adapt, and one farm type (Rubber and Business) was more likely to adapt.

415

416 Redundancy analysis confirmed that farm characteristics variables explained a significant but low proportion of  
417 the variance within the farmer motivations variables (5% of the variance,  $p < 0.001$ ). Livelihood strategy (income  
418 generating activities) explained 2.5% of the total variance in motivations variables, altitude explained 1.4 %,  
419 household demographic information explained 1.2%, the number of agricultural activities and off-farm activities  
420 explained 1% and farm size explained 0.2%.

421



#### 422 **4. Discussion**

423

424 While we found a statistically significant link between farm types and farmers' motivations to adapt their  
425 behaviours, the predictive power was low. A farmer's motivations could not, in this case, be reliably inferred from  
426 his livelihood and farm characteristics without having gathered separate, specific information regarding  
427 motivations. Such data is not usually collected, and socio-demographic proxies are usually used instead  
428 (Pattanayak et al., 2003). In this study, the usual proxies (age, ethnicity, education) showed no significant  
429 predictive power of farmers' motivation type. Our results here show that predicting how likely a farmer is to adapt  
430 his behaviour based on the usual farm typology data of farm structural characteristics, livelihoods or  
431 demographics (van der Ploeg et al., 2009) is not a very reliable strategy, and that consideration of 'intrinsic  
432 motivations' (Meijer et al., 2014) should be done separately. However, we acknowledge that further work is  
433 required to test the degree to which these motivation types accurately predict actual behaviour. A panel survey  
434 approach would be very valuable in this regard, particularly where farmers' responses to an intervention or set of  
435 interventions could be monitored.

436

437 When considering the farmers' motivations types and the farm types in combination, the most striking observation  
438 was that the full range of motivations type was found in every farm type, albeit with some differences in relative  
439 proportions (see Figure 3). This has significance for the number of households who would be interested to adapt  
440 their behaviour, and potentially become adopters of a new practice, any program could realistically expect to  
441 engage: across the whole population only about 25-35% of households are motivated to and willing to try out new  
442 innovations (Aspirational Innovators and Conscientious motivation types), and potentially about 40% of  
443 households could be expected to take up innovations once proven successful by other users and assuming that  
444 appropriate support mechanisms were in place (Copy Cats, Incentive-centric and Well Settled motivation types),  
445 and the remaining 25% of households were very resistant to uptake of new innovations (Change Resistant) (Tables  
446 4 and 5). In the 'diffusion of innovations' literature potential adopters are classified into five groups, ranked in  
447 decreasing order of eagerness to adopt new products or practices; innovators, early adopters, early majority, late  
448 majority and laggards (Rogers, 2010). These classifications could well apply in the present study, whereby the  
449 Aspirational Innovator type equates with the innovator group, Conscientious type the early adopters, Copy Cats  
450 early majority, Incentive-Centric and Well Settled types sitting somewhere between the early majority and the late

majority, and finally the Change Resistant type as the laggards (although it should be stressed that the present study assessed willingness to adapt behaviour in a variety of ways, rather than willingness to adopt a specific practice). The relative proportions of the population who fall into these categories and their structural characteristics has long been studied in marketing literature (Uhl et al., 1970) but not so much in the development literature, so it is difficult to know if the proportions we have identified are replicated in other locations. There are also strategic implications as to which groups should be targeted by programs promoting new innovations – initial focus on the more innovative types is likely to bring about a higher adoption rate due to the higher willingness of those groups to adapt their behaviours, but the most innovative may not be the most in need of assistance.

The motivations data can also be used to inform the design of mechanisms that encourage farmers to adapt their behaviours. Typically such mechanisms are grouped into awareness raising/education, regulatory instruments, and economic incentives. Probably the most widely used mechanism is subsidy, although many others exist. We found that about half of the population appeared to be strongly motivated by economic factors – the Aspirational Innovators and Incentive-centric motivational types – but that only the Aspirational Innovators were generally willing to adapt and try out new practices (see Tables 4 and 5). The Incentive-centric cluster scored highly on innovation values, but showed a relatively low willingness to adapt their behaviour and cited more obstacles to behaviour change than most other clusters (see Figure 2), therefore subsidies alone are unlikely to motivate them to trial new practices. In line with other research in Xishuangbanna, we therefore suggest that subsidies are not the most appropriate mechanism to encourage a change in behaviour (Smajgl et al., 2015b; Wigboldus et al., 2016; Yi et al., 2014b), but should form part of a wider strategy of removing obstacles to adaptation. It is interesting to note that out of the four scenarios outlined to participants in this study, the one which elicited the most positive response from participants was the government subsidy program for native trees replacing rubber trees to match present income – but also that a small number of households also rejected this scenario with the reason that they did not believe it was feasible. With mean rubber incomes at around 9000 USD per year for a rubber growing household at the time of the study (Table 3), it is indeed almost impossible that such a high subsidy scheme could be offered.

Awareness raising and educational mechanisms to encourage adoption appear to be the most necessary. The number one cited reason that households did not wish to adapt was that they did not see the relevance of external

480 changes to themselves (Figure 2). In order to increase the perceived imperative to adapt, making interventions  
481 relevant to issues which the potential users consider important seems sensible. All groups reported strong  
482 identification with their sense of place (almost all respondents would not consider leaving) and reported high  
483 importance of family. Financial variables were considered very important for about half the households, and few  
484 groups reported much concern about environmental variables. Environmental benefit is a key driver for science  
485 and policy efforts to curb unsustainable land use (Ahrends et al. 2015)□, and although there is widespread  
486 agreement amongst respondents that ecosystem services related to water, soil and biodiversity are declining (Table  
487 4), only about 11% of the surveyed population appeared motivated by such messages (the Conscientious  
488 motivation type). Messages which appeal to sense of place and long term benefit to family might therefore be  
489 more successful than messages relating to environmental impacts. These findings are in line with recent work  
490 based on integrative qualitative assessment in Xishuangbanna (Wigboldus et al., 2016).

491

492 More material barriers to adaptation such as lack of money, lack of skills or lack of land are cited considerably  
493 less frequently (Figure 2). Although this has also been reported elsewhere (Kiptot et al., 2007), it is often  
494 overlooked in the design of projects which aim to promote new agricultural practices. We found that general  
495 resistance to change was a greater impediment to adaptation than the more material or specific issues which  
496 government/development programs often seek to address. This trend is particularly marked for the clusters which  
497 are more likely to be early adapters – the Aspirational Innovators, Conscientious and the Copy Cats. These data  
498 suggest that in order to achieve higher adoption rates, interventions should be accompanied by educational and  
499 participatory components which respond to the needs identified as important to the farmers: an explanation of the  
500 problem the intervention addresses, a realistic exploration of the risk profile, and a sensitive, pragmatic  
501 consideration of how the intervention would interact with the farmers' existing work schedules. Such nuanced  
502 trappings require re-organization of traditional research modes into a more dynamic configuration (Schut et al.,  
503 2014), and need strong relationships with community members which preclude the falsely efficient 'one size fits  
504 all' development packages which can be deployed in multiple locations.

505

506 The overall picture from the survey data however is of a society which is fairly well satisfied, wealthier than most  
507 developing world farming communities, and quite mixed in terms of adaptation and trying new ideas. People are  
508 generally optimistic about their future, and believe that they will continue farming and their standard of living will

509 continue to improve. This optimism may be founded upon the rapid upwards trajectory of development in  
510 Xishuangbanna and in China as a whole over the past few decades. We cannot say if the findings of the  
511 motivations typology and the weakness of the link between farm type and motivation type would be the same in  
512 poorer and more desperate locations. It would certainly be worth testing.

513

514 Whilst scientists are seriously concerned about the risks posed by declining levels of biodiversity, soil health and  
515 economic vulnerability due to rubber cropping (Ahrends et al., 2015; Warren-Thomas et al., 2015), concerns about  
516 economic well being predominate amongst the local population (Wigboldus et al., 2016) and rubber farming has  
517 been the route out of poverty for most households surveyed. This is not a society which would be easy to  
518 influence unless some sort of crisis were to destabilise the social equilibrium. Such an opportunity may be  
519 provided by the crash in rubber price from over \$6 per kg in 2011 to approximately \$1.5 per kg in 2013. The time  
520 may well be ripe for a combination of financial incentives and educational messaging which promotes alternative  
521 land use practices, with government and private sector efforts to develop associated infrastructure and markets for  
522 alternative crops. Motivations typologies might be useful in design and targeting of such a strategy.

523

524 If motivations data can be used to understand how many households might be expected to adapt, at what point in  
525 time (e.g. early adopters, late adopters), and to help design promotional mechanisms for interventions, farm  
526 structural characteristics data is useful to inform what those adaptations could be. Interventions proposed for  
527 making rubber more sustainable can be divided into four broad categories: improved farming practices and  
528 technology, improved knowledge and awareness, market and value chain measures, and policy measures. Market  
529 and value chain measures could be a promising avenue, as some households report running their own small  
530 businesses, and the entrepreneurial Rubber and Business farm type accounts for about 20% of the total population  
531 (Tables 2 and 3). Likewise, amongst the more impoverished upland farmers, private businesses are a major source  
532 of income and may indicate the entrepreneurial basis required for value chain developments. Farm practice  
533 interventions can be further subdivided into two types: modifying rubber management (e.g. less pesticides,  
534 planting density, alternative hybrids) and alternative crops (e.g. intercropping, land use zoning). Alternative crops  
535 obviously require a route to market in order to be a viable option, which is why the value chain measures are so  
536 important. Changes to rubber management may be easier therefore to achieve in the short term, but are affected by  
537 the concerns outlined regarding adoption rates and connecting to farmers' motivations. The Traditional Rubber

538 farm type – the largest of all the farm types – would be the most difficult to influence regarding changes to farm  
539 management. The household heads tend to be older, less educated, they tend to have lower cropping diversity  
540 (Table 3), and the Tradition Rubber farm type contains more Change Resistant and Well Settled motivation types  
541 than any other farm type (Figure 3). Interventions regarding changes to farming practice may therefore be better  
542 targeted towards younger household heads (Young Rubber), or households which are already engaged in a greater  
543 diversity of cash crops (Mixed Cash Croppers) (see Tables 2 and 3). The Upland Mixed farming cluster are also  
544 worthy of further discussion: they were the poorest cluster, and had the lowest profit rubber plantations, which  
545 were established at elevations 700-900 metres, around the maximum elevation where rubber trees can be  
546 profitably grown (Yi et al., 2014a). These farmers may be especially hard hit by the rubber price crash, as their  
547 plantations are now unlikely to be viable. Subsidy schemes and participatory training methods to encourage  
548 alternative cropping linked with value chain developments and ecological management of high elevation water  
549 courses might be especially appropriate for the upland farmers.

550

551 The implications for improving adaptation rates through enhanced understanding of farmers' motivations have  
552 significance for tropical farming systems broadly, indeed in any site where the development interventions are  
553 proposed by actors who have a different world view and different priorities to the intended users. This  
554 appreciation of the users' needs and motivations has often been overlooked (Meijer et al., 2014; Pattanayak et al.,  
555 2003) and can help to achieve the appropriate service delivery mechanisms and co-learning methods identified as  
556 key to achieving up-scaling in agricultural development (Coe et al., 2014; Schut et al., 2014). The approach we  
557 trialled appears to yield useful information and we propose that it should be further developed and tested.  
558 Particularly useful were the questions on guiding values developed from the field of social psychology (de Groot  
559 et al., 2008). These questions were extensively tested in the European context (de Groot and Steg, 2007), and that  
560 they delivered useful findings in an Asian context is promising for the global applicability of this method. The  
561 value orientation questions could however be modified to better suit the local context, and the scoring system  
562 could be improved encouraging respondents to use the full range of the scale. The scenario questions were also  
563 very useful in determining stated willingness to adapt behaviour (contingent upon hypothetical events), and the  
564 perceived obstacles to adaptation, although most of the detail gathered in follow up questions was not useful in  
565 this analysis. In future it may be better to ask about more scenarios but with less follow up questions. The  
566 questions asked about attitudes, satisfaction and future perceptions were less useful in differentiating households

567 in this study. With these further refinements it might be possible to develop a more streamlined suite of questions  
568 which would allow rapid exploration of farmer motivations, without resorting to inaccurate assumptions based on  
569 socio-demographics or livelihood proxies.

570

571

## 572 **5. Conclusions**

573

574 Six farm types were identified, four of which relied primarily on rubber crops and could be considered wealthy by  
575 regional standards. Six motivation types were also identified, ranging from farmers who were most likely to  
576 innovate, farmers motivated primarily by income or by community and environmental benefit, to farmers reluctant  
577 to innovate under any circumstance. The full range of motivations types were found in all six farm types, albeit  
578 with a small but significant variation in proportions between farm types. This has two implications: (i) when  
579 designing interventions for a group of farmers defined by their farming practice, the full diversity of motivational  
580 orientations should be considered, and only a sub-group of those farmers should be expected to engage actively  
581 with new interventions; and (ii) in order to understand farmer motivations additional data is required beyond the  
582 usual farm characteristics and livelihood information. We found that an assessment of value orientations (Smajgl  
583 and Ward, 2015; Stern et al., 1998), along with stated response to some hypothetical external influences and a  
584 simple rating of overall life satisfaction data types were the most useful in defining farmers' motivations to adapt  
585 their behaviour.

586

587 Rubber farmers in the study population are wealthy by developing world standards, and any proposed changes to  
588 their farming practice would need to compete economically with mean incomes of around 9000 USD per year per  
589 household. However, due to the recent rubber price crash, households may now consider alternative activities with  
590 lower incomes. Maintaining adequate income is only one factor which motivates households, with about half the  
591 population strongly motivated by income, but messages which appeal to a sense of place and family well being  
592 have wider appeal. Without widespread awareness raising and education, arguments using environmental  
593 degradation as a motivating message for farmers to adapt their behaviour are unlikely to achieve much success.  
594 The obstacles to adaptation which were identified most frequently were conceptual rather than material:  
595 households felt that changing their behaviour would be unnecessary and irrelevant rather than feeling that they

596 lacked the skills or capital in order to make changes. Amongst the study population, only about one third could be  
597 classed as keen to innovate and try out new practices, which, if found to be true elsewhere, explains in part the  
598 challenge of promoting new agricultural interventions more generally.

599

600

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602

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798 **Tables**

799

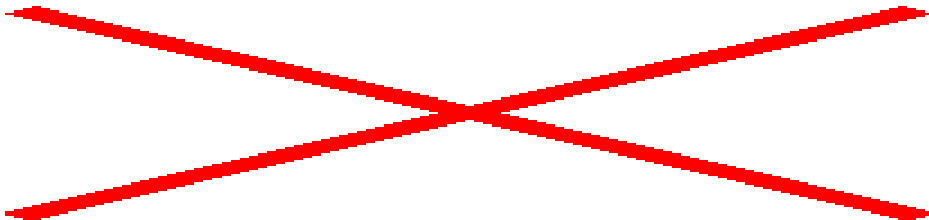
800

801 Table 1. Sampling structure of the households surveyed within Xishuangbanna. Jurisdictional levels  
802 within the province of Xishuangbanna are county, township, village committee (a group of villages  
803 represented by a common government committee), and finally natural villages (normal villages – a  
804 group of houses located close to one another).

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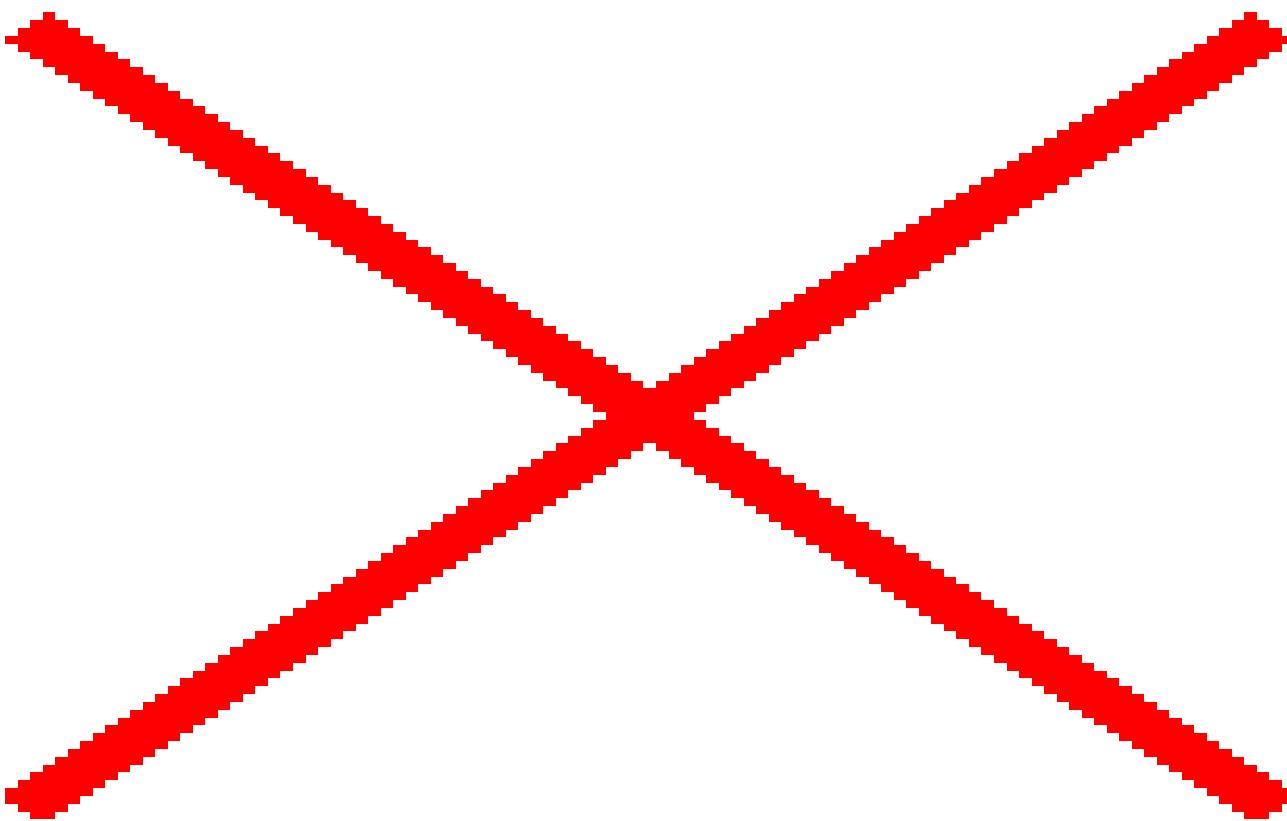
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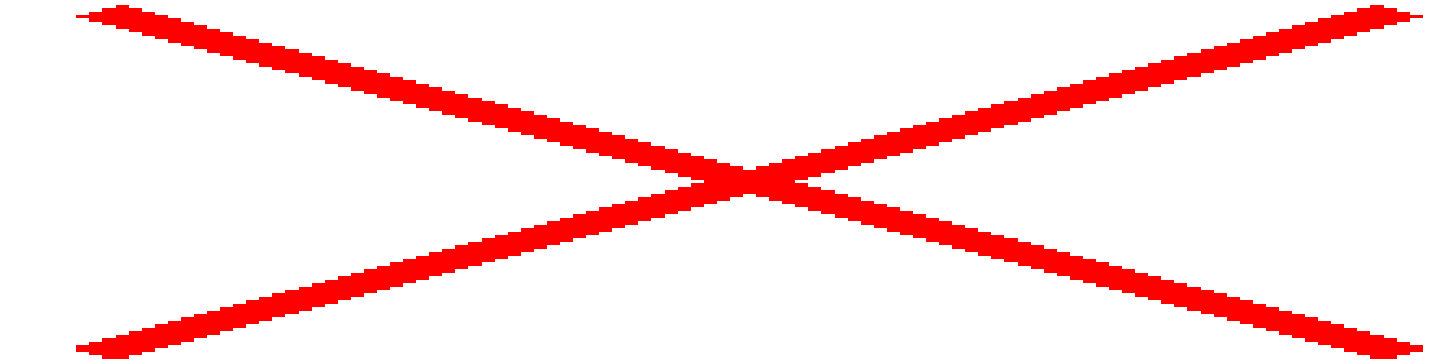
809   Table 2: Verbal descriptions and comparisons of the farm types based on structural characteristics  
810   and livelihoods. Differences mentioned are significant at 95%, tested with Tukey's HSD, and  
811   individual pairwise comparisons are shown in Table 3.

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813

814 Table 3. Numerical descriptions of the farm types based on structural characteristics and  
815 livelihoods. Mean values are shown, with all incomes in USD and gross values. Letters after the  
816 numbers indicate significant differences between clusters, at  $p < 0.05$ , using the Tukey HSD test.  
817 Abbreviations: ‘Agric.’ means agricultural, ‘excl.’ means excluding, ‘HH’ means household.  
818 Educational level was converted from ordinal to numerical data, where 0 means illiterate, 1 literate,  
819 2 primary, 3 secondary and 4 post-secondary.



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825 Table 4: Verbal descriptions and comparisons of farmer motivations clusters. Differences mentioned  
826 are significant at 95%, tested with Tukey's HSD, and individual pairwise comparisons are shown in  
827 Table 5.

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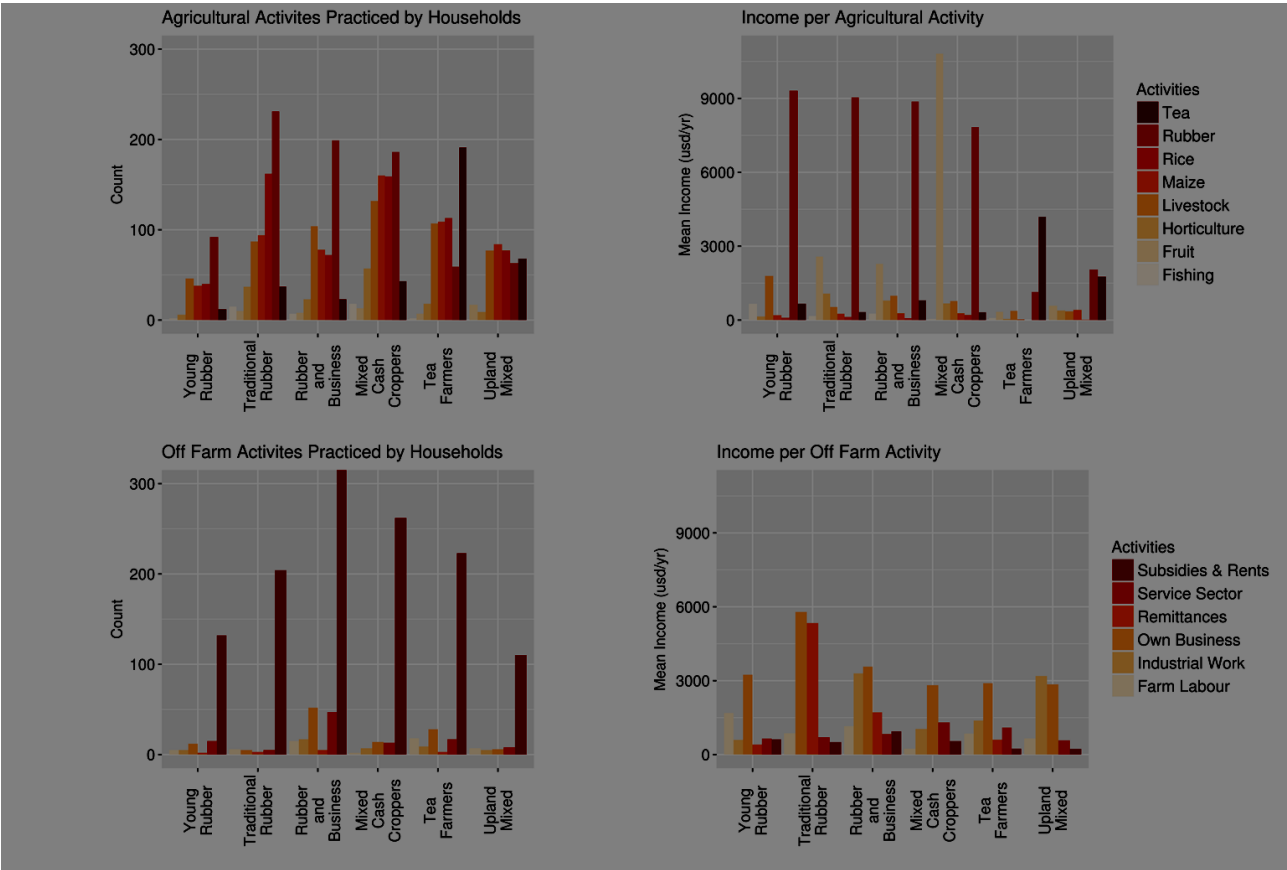
833

834 Table 5. Numerical descriptions of the Farmer Motivation types. Mean values are shown, and all  
835 variables are scored between 0 and 10, except for ‘Ignore Scenarios’. Ignore Scenarios is scored 0  
836 to 4, where 0 means that the respondent chose to respond in some way to all four scenarios, and 4  
837 means they chose to ignore (not respond) to all four scenarios. Letters after the numbers indicate  
838 significant differences between clusters, at  $p < 0.05$ , using the Tukey HSD test.

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**Figures**

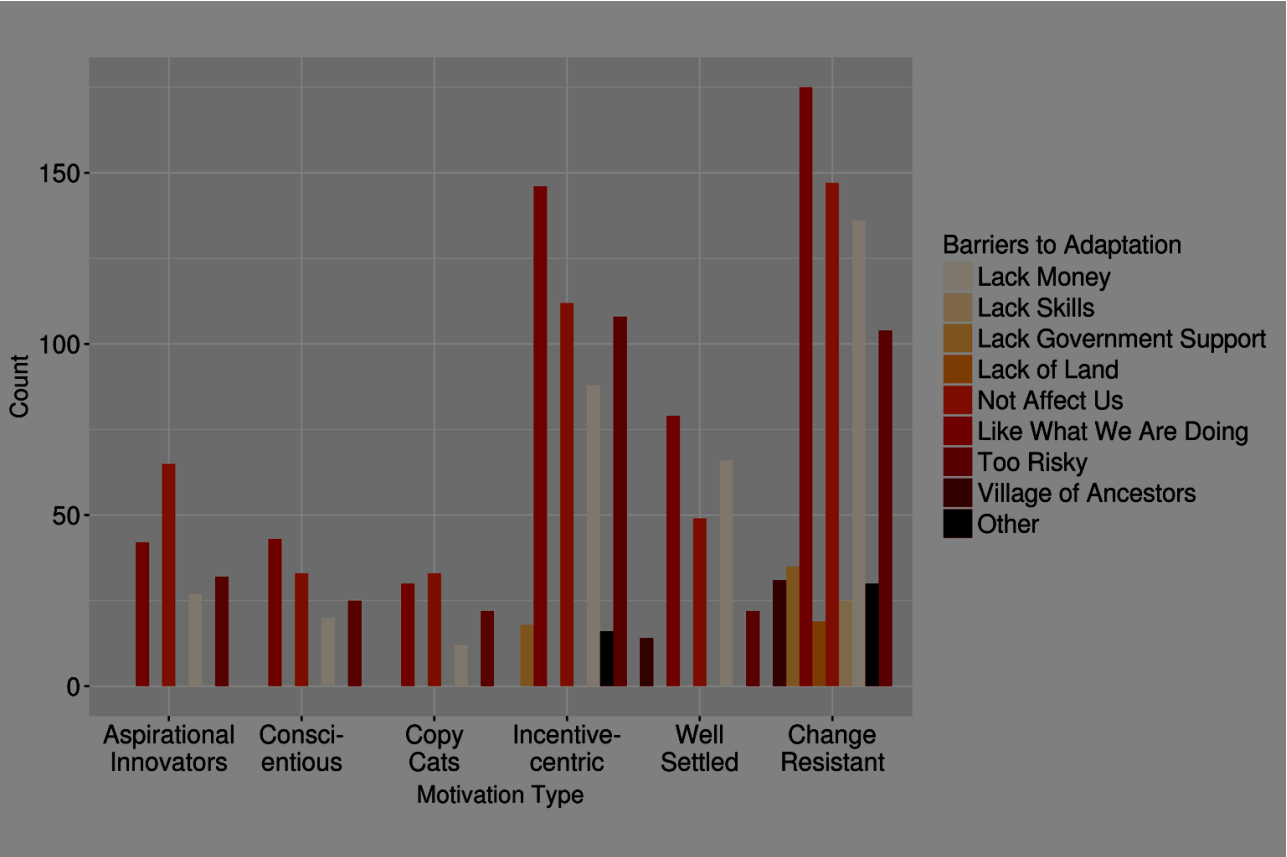
Figure 1. Livelihood activities by farm type. The frequency that agricultural activities and off-farm activities are reported for household and the mean income for each activity is shown. Note that the total height of the bars for mean income of each activity does not equal the mean income of a household in that cluster, as not every household takes part in every activity. The mean household incomes per farm type are shown in Table 3. The total number of activities reported may be larger than the number of households in a cluster because some of the categories are made up of a more than one activity. Note that the total number of activities relating to Subsidies and Rent reported by the Rubber and Business farm type was 434, but the axis scale was limited to enhance overall readability.



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852 Figure 2: Reasons given by motivations clusters for why they would choose not respond to one or  
853 more of the four hypothetical scenarios outlined to them – i.e. why they would choose not to adapt  
854 their behaviour to an external stress. Some clusters chose not to respond to scenarios more  
855 frequently than others.

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861 Figure 3: The proportions of motivation types found within each farm type. The distribution of

862 motivation types amongst farm types is significantly non-random (Chi squared test,  $p<0.01$ ), and it

863 can be seen that some farm types contain visibly more of certain motivation types than others. Note

864 that the motivation types are ordered from most likely to adapt ('Aspirational Innovators') to least

865 likely to adapt ('Change Resistant').

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